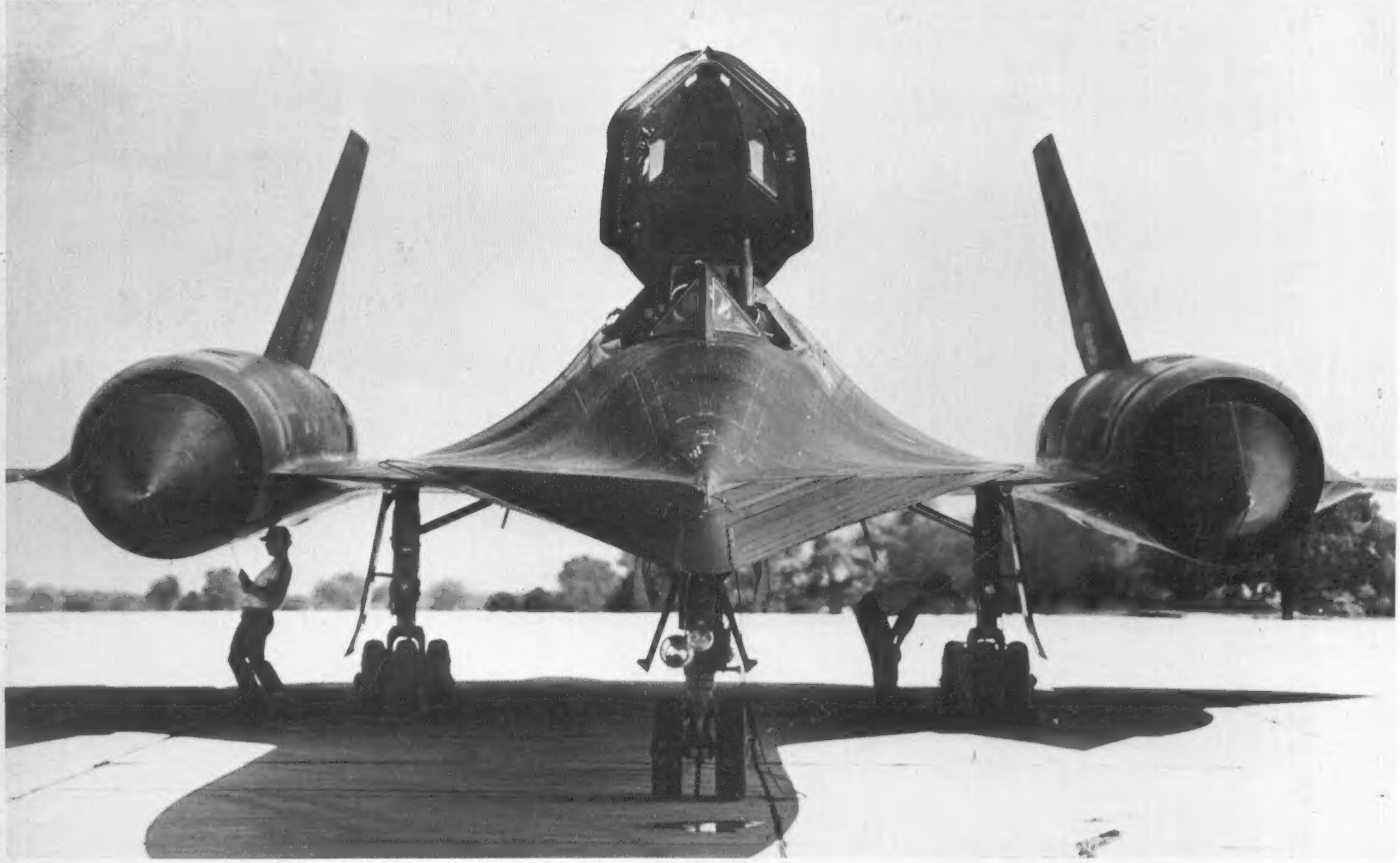
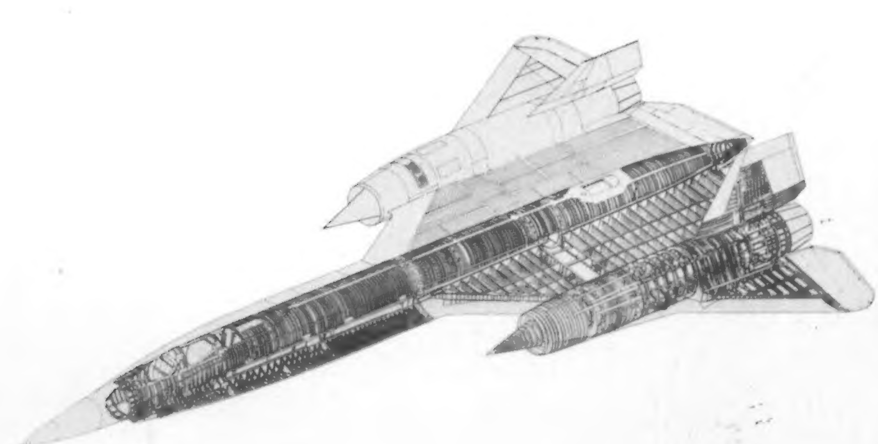


Aerofax Minigraph 1

Lockheed SR-71 (A-12 / YF-12 / D-21)

by Jay Miller



Aerofax, Inc.
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A-12 Overview

John Andrews collection

Eight A-12's and two F-12's (last two aircraft at back of row) line the main ramp at Groom Lake during the course of the flight test program in 1963. Closest aircraft is A-12 prototype, 60-6924; second aircraft is two seat trainer, 60-6927.

John Andrews

Direct front view of two -seat A-12 emphasizes chine.

John Andrews

Rear view of single-seat A-12 shows elevons and empennage section details.

John Andrews

Two-seat A-12 stored at Lockheed's Palmdale, Ca. facility.

John Andrews

A-12 nose chine is somewhat more pleasing than that of the SR-71 and offers a cleaner transition.

THE LOCKHEED A-12/F-12/SR-71 STORY

CREDITS:

Aerofax, Inc. would like to give special thanks to John Andrews of the Testor Corp., and Jim Goodall, without whose help this effort would be seriously deficient. Additionally the assistance provided by Ben Rich and Bob Ferguson of Lockheed-California Co., Bob Stangarone of Pratt & Whitney Aircraft Group, John W. R. Taylor of *Jane's All The World's Aircraft,* René Francillon, Ph.D., Chris Pocock, Dave Menard, Tom Brewer, Col. Richard Uppstrom, NASA Dryden, Susan Miller, Bruce Hallock, Danny Schweers, Bob and Alice King of King's Hobby Shop, and James Stevenson should not be forgotten.

PROGRAM HISTORY:

The birth of what is today the world's most famous and paradoxically most enigmatic reconnaissance aircraft can be traced back to March of 1954. A British engineer by the name of Randolph Samuel Rae, at the time employed by the Summers Gyroscope Company in Santa Monica, California, submitted to the USAF's Air Research and Development Command an unsolicited proposal for a three-stage propeller-turbine-powered aircraft fueled by liquid hydrogen and liquid oxygen. Rae's proposal was reviewed by the ARDC and in October of 1955, following the acquisition of rights to Rae's propulsion concepts, the Garrett Corp. was awarded a study contract to further explore its possibilities.

Funding for an aircraft design study calling for *Rex I, II,* and *III* liquid hydrogen powerplants led to a two month study subcontract to Lockheed-California Company of Burbank, California, wherein the latter would be responsible for development of the airframe. The resulting preliminary design, known as the CL-325-1, had a thin, straight wing and a very slender fuselage. Propulsion was to be provided by two *Rex III*'s generating 4,500 lbs. th. ea. With a span of 79′ 10½″, a length of 153′ 4″, and a gross take-off weight of 45,705 lbs., the CL-325-1 was expected to cruise at Mach 2.25 and 100,000′ over a range of 3,500 miles. The CL-325 eventually evolved into a more advanced configuration known as the CL-325-2, with external fuel tanks and other changes. By mid-1957, however, interest in the program had waned and A.F. representatives were convinced that development of the *Rex* powerplant would be significantly more difficult than anticipated.

Lockheed, in the meantime, under the auspices of their legendary advanced development projects office (nicknamed the "Skunk Works") director, Clarence L. "Kelly" Johnson (with the very able assistance of fellow Lockheed engineer Ben Rich), forged ahead with still more advanced hydrogen fueled designs of their own. Among these was the extraordinary CL-400. This aircraft, having a wingspan of 83′ 9″, a length of 164′ 10″, and a gross take-off weight of 69,955 lbs., was a dedicated reconnaissance platform offering a cruising speed of Mach 2.5 over a range of approximately 2,500 miles. Lockheed, with Johnson ramrodding the effort, managed to secure an A.F. contract (under the auspices of the ultra-secret A.F. "Suntan" liquid hydrogen fueled aircraft program) in April of 1956. This called for the development and construction of two prototype CL-400's.

Eighteen months were allocated for the completion of these first two aircraft (to be followed by six production samples), and work reached a feverish pitch in very short order following contract signing. Within a year of the initiation of construction, however, Johnson began to develop serious doubts about the project and particularly the practicality of liquid hydrogen as an aircraft powerplant fuel. Finally, in October of 1957, he recommended to the A.F. that the program be cancelled and replaced by one of more conventional aspirations.

The resulting realignment gave birth to a new high-speed, high-altitude, long-range reconnaissance aircraft program that was funded by the Central Intelligence Agency under the auspices of the USAF. Several contending designs were eventually proposed for consideration, including General Dynamics' Mach 6-cruise *Fish* and *Kingfish* ramjet-powered deltas, and the Navy's radical inflatable rubber machine also powered by ramjet engines, but Lockheed's slightly more conservative all-titanium double delta, program code-named *Oxcart,* eventually proved the winner.

One of a series of A-designated design studies, the first of the Lockheed aircraft, officially referred to as the A-12 and soon to become the first Mach 3+ cruise-capable aircraft in the world, was virtually complete by December of 1961, some 26 months after program approval. Delivered almost completely assembled by two trucks and a special trailer to the Air Force's classified Groom Lake flight test facility (nicknamed "The Ranch") in south central Nevada, in mid-January of 1962, the first "Article" (as Lockheed and associated agencies also surreptitiously referred to the A-12) was reassembled over a period of weeks in one of several large Groom Lake hangars and prepared for first flight. Following preliminary ground and taxi tests, the first official flight was successfully completed by company test pilot Lou Schalk on April 26th (a high speed taxi test had resulted in an inadvertent first "hop" on the 24th).

Initial flight testing of this first A-12, 60-6924, began with two P&W J75 turbojets in place of the P&W J58's called for in the full production aircraft. It wasn't until seven months later that flights with J58's in both engine nacelles first took place.

Problems with engine/intake interfacing at high Mach numbers, coupled with myriad others relating to construction materials, fuels, lubricants, crew environment, sensor systems, structure, landing gear, and virtually every other major or minor aspect of the aircraft, plagued it for the first two years of the flight test and operational evaluation program. The Central Intelligence Agency, representing the main impetus behind the A-12, had begun to accept the first of an initial batch of ten aircraft in late 1962. An additional five eventually joined this mixed test and operational evaluation A-12 fleet, spaced apart by three dedicated interceptor testbed aircraft.

The latter eventually became known as YF-12A's and differed from the preceding ten aircraft in having a long range Hughes AN/ASG-18 radar in the nose, provisions for the advanced Hughes GAR-9 (AIM-47A) air-to-air missile in fuselage bays, the addition of a folding center ventral fin, and a substantially revised nose configuration (to accommodate the radar and infra-red sensors) and forward fuselage chine. Additionally, and importantly in consideration of the fact that it presaged the forthcoming SR-71 crew accommodations, the YF-12A's were two-seat aircraft. The A-12's had been single-seaters (with the exception of the single trainer modification and the two D-21 transports described later) and the rear compartment (referred to as the "Q-bay") had been reserved for sensor equipment (à la the precedent-setting U-2).

The first YF-12A, 60-6934, made its first flight on August 7, 1963, also from Groom Lake, Nevada. This was followed by an extensive multi-disciplined, multi-sponsor flight test program, in concert with its two stablemates (60-6935 and 60-6936) that was to continue unabated until November 7, 1979, when 60-6935 was delivered, on its final flight, from Edwards AFB to the A.F. Museum in Dayton, Ohio, for permanent display.

During the course of the two year period following the first flight of the first A-12, the entire program, due its CIA connection and the obvious technology advances, remained highly sensitive both politically and technologically. No information relating to the program was publicly released. Finally, however, on February 29, 1964, President Lyndon B. Johnson announced during a news conference that the program existed and that the actual hardware (referred to erroneously at the time as the A-11; the first photos released actually illustrated the prototype YF-12A, 60-6934) was being flight tested. Four months later, on July 24, Johnson also broke the news that Lockheed was developing a more advanced dedicated reconnaissance version that was to be known as the SR-71. Following Johnson's official *Blackbird* program unveiling, the A.F. elected to use the YF-12A's to set a series of absolute world speed and altitude records as well as records for Class C Group III. These records, set on May 1, 1965, were: sustained altitude (absolute)—80,258′ (crew, Col. Robert Stephens/Lt. Col. Daniel Andre); 15/25 km closed circuit (absolute)—2,070.102 mph (crew, Col. Robert Stephens/Lt. Col. Daniel Andre); 500 km closed-circuit (Class C)—1,643.042 mph (crew, Maj. Walter Daniel/Maj. Noel Warner); 1,000 km closed-circuit without payload and with 1,000 kg payload (absolute) and with 2,000 kg payload (Class C)—1,688.891 mph (crew, Maj. Walter Daniel/Capt. James Cooney). Interestingly, the CIA-dedicated A-12, the YF-12A's immediate predecessor, was a somewhat faster and higher flying aircraft. The A-12's performance permitted a maximum speed of Mach 3.6 (approximately 2,400 mph) at an altitude of 92,500′—well in excess of the records set by the YF-12A.

A need for flight instruction in the A-12 eventually resulted in the first trainer modification of the *Blackbird* program. One airplane was purpose-built as a two-seat configuration with an elevated rear cockpit. This modification, incorporating J75 powerplants in place of the J58's (which limited the maximum speed capability to about Mach 1.2), was a permanent fix and the mod entailed more than a simple reconfiguration of the aft "Q-bay."

Additionally, two single-seat A-12's (also referred to as M-12's and each nicknamed "Mother Goose") were modified to accommodate a launch control officer's seat in the "Q-bay" for monitoring D-21 functions during ascent and pre-launch. The D-21, a Mach 4.0 cruise low radar and infra-red signature Marquardt RJ43-MA-11 ramjet engine-powered drone with a wingspan of 19′, a length of 43′ 2″, and a gross weight of approximately 20,000 lbs., was carried by the two specially modified A-12's on a simple dorsal pylon mounted on the empennage between the two vertical tail surfaces.

The D-21 program, which resulted in the construction of some 38 vehicles, was relatively short lived due to serious problems with launch procedures (one of the two A-12's converted for D-21 transport was destroyed and its launch control officer lost during a D-21 test launch that failed) and program political sensitivity, and little has been revealed of its performance or service use. It is known that the D-21 was considered an expendable vehicle and, following a mission over hostile territory, it would return to a recovery area, eject its sensor system imagery (which would be recovered by specially modified C-130's during parachute descent), and then be destroyed by an internal explosive. Most operational D-21 missions were launched from two Boeing B-52H carrier aircraft operating with the unique Beale AFB-assigned 4200th Test Wing.

The SR-71, first ordered in an initial batch of six aircraft on December 27/28, 1962, and soon to become the best known of the *Blackbird* family, was a major redesign of the original A-12 configuration which, by 1967, was beginning to reach the end of its political life and was also becoming redundant to more advanced intelligence systems made accessible to the CIA. The last A-12 flight, in fact, took place in June of 1968, and following its retirement, all missions requiring A-12 capabilities were accomplished using the SR-71A.

Bigger, heavier, and internally more commodious than its predecessors, the SR-71A offered increased range and a slightly greater payload while also providing accommodations for a badly needed second crew member. The latter, eventually referred to as an RSO (Reconnaissance Systems Officer), was a dedicated technician whose primary concerns were the aircraft's extensive array of electronic and optical sensors, and its passive and active electronic warfare systems.

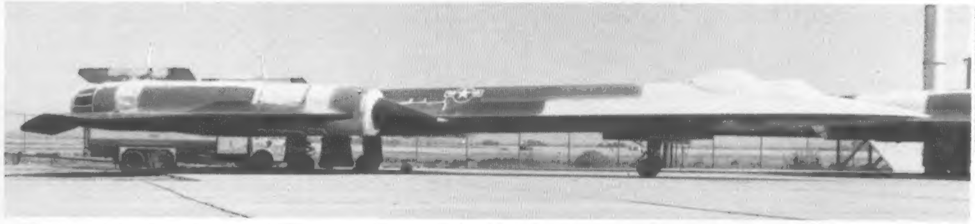
The SR-71 first entered the operational A.F. inventory on January 7, 1966, with the delivery of 64-17956 to the 4200th SRW at Beale AFB, California. The first flight of the first prototype SR-71A, 64-17950, had taken place at Palmdale, California on December 22, 1964, following final assembly of the aircraft in Air Force Plant 42, Site 2 operated by Lockheed-California Co.

Following SR-71A service introduction under the auspices of the 4200th SRW, this unit was reorganized six months later as the 9th SRW at the same base. This occurred officially on June 22, 1966 and two squadrons, the 1st and 99th SRS's, were involved. Eventually, the 99th was disbanded for cost reasons and the 1st took over full responsibility as the sole 9th SRW squadron. During 1976, the 99th SRS reformed to operate the U-2C and U-2R, acquiring aircraft from the 349th SRS 100th SRW at Davis-Monthan AFB. The latter also reformed at Beale to become the 349th ARS 100th ARW and was assigned full responsibility for the dedicated KC-135Q/SR-71 tanker aircraft.

SR-71 deployments to Kadena AB on Guam and to RAF Mildenhall in the United Kingdom are made at regular intervals and a permanent facility operating at

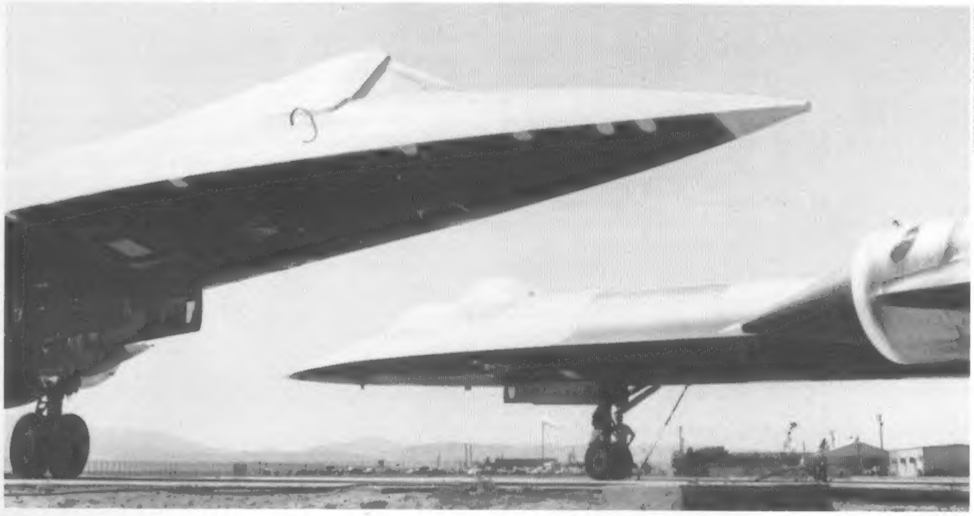
Lockheed-California Co.

Only A-12 inflight photo released to date depicts 60-6932.



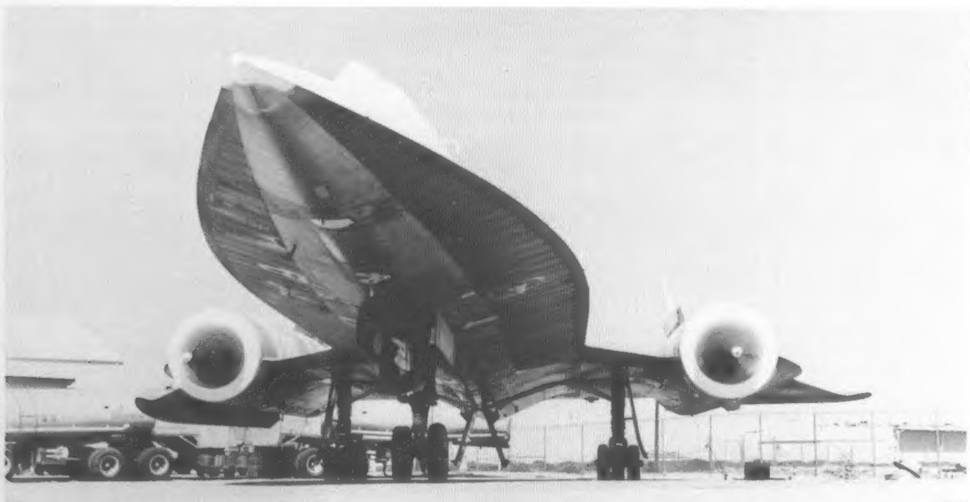
John Andrews Collection

Two-seat A-12, nicknamed "Titanium Goose", has second crew station in sensor system "Q-bay".



John Andrews Collection

Comparison of single-seat and two-seat A-12 forward fuselage sections.



John Andrews Collection

A-12 chine is significantly more tapered than that of SR-71.

least two SR-71A's (now sporting new low-visibility markings which consist of nothing except small red serial numbers on the vertical tail surfaces) continuously is now in place at the latter. Temporary deployments to Forward Operating Locations, worldwide, have been recorded and it is known that SR-71 mission assignments have taken the aircraft to virtually every strategically and politically important spot on the globe. Non-stop missions in excess of 14,000 miles have been documented. The 9th SRW continues as the sole operating unit assigned SR-71A's, and will likely remain as such throughout the remaining service life of the aircraft.

The previously mentioned YF-12A speed and altitude records were superceded by the SR-71A during a series of FAI monitored flights in 1976. To date, almost all of these records still stand, most notably, the world's absolute speed and altitude records set on July 27, 1976: height in sustained horizontal flight—85,069′ (crew, Capt. Robert Helt/Maj. Larry Elliot); speed in a straight line—2,193.17 mph (crew, Capt. Eldon Joersz/Maj. George Morgan, Jr.); and speed over a 1,000 km closed circuit—2,092.294 mph (crew, Maj. Adolphus Bledsoe, Jr./Maj. John Fuller). Other records set by the SR-71A include, on April 26, 1971, a non-stop 15,000 mile mission flown in 10½ hours (crew, Maj. Thomas Estes/Maj. Dewain Vick—awarded the 1971 Harmon and Mackey trophy for the flight); on September 1, 1976, a non-stop flight from Beale AFB to RAE Farnborough in which the New York to London (3,490 mi.) segment was flown in 1 hr. 55 min. 42 sec. (crew, Maj. James Sullivan/Maj. Noel Widdifield); and a non-stop flight on September 13, 1976, from London to Los Angeles (5,645 mi) in 3 hr. 47 min. 39 sec. at an average speed of 1,487 mph (crew, Capt. Harold Adams/Maj. William Machorek).

CONSTRUCTION AND SYSTEMS:

All three of the basic *Blackbird* variations have been built to the same materials and structural standards. The primary construction material is Beta B-120, a titanium alloy developed in a joint effort by Lockheed and the Titanium Metals Corporation. Beta B-120 makes up 93% of the A-12's empty weight. It has a tensile strength of up to 200,000 pounds and its structural integrity in high heat sink situations remains inordinately high. By the cubic inch, aged B-120 weighs half as much as stainless steel yet offers similar strength properties.

The fuselage core consists of a tubular center with blended chines running the full length of the tube from nose to wing leading edge (the YF-12A chine breaks at the nose cone/fuselage intersect). In order to achieve the exceptional range objectives specified in the original proposal, much of the internal space of the three basic variants is occupied by fuel tankage. Approximately two-thirds of the fuselage and half the wing space available is devoted to the 84,180 pounds (12,200 gallons) of fuel carried by the SR-71.

The fuel, Shell Oil Company-developed JP-7, serves as a heat sink for the entire aircraft (including crew member suit cooling requirements) and its distribution in consideration of cg and dynamic load requirements (the SR-71A and its predecessors are considered to be "low Q" airframes) is maintained automatically. Nitrogen is used to pressurize the fuel tanks and also to prevent inadvertent vapor ignition. An inflight refueling receptacle is mounted on top of the fuselage behind the rear cockpit.

The fuselage cants upward some 2-deg. from the centerline in order to reduce trim drag at high Mach. Tailcone configurations vary somewhat between the three variants. The A-12 and YF-12A tailcones are relatively short, whereas that of the SR-71 is noticeably longer (in order to improve overall fineness ratio and increase internal fuel capacity). Additionally, a classified "long tail" configuration has been tested on the SR-71, this accommodating special optical sensors and offering increased space for other sensor types.

The wing is a cantilever design of basically delta planform with a modified bi-convex section of 2.5% thickness/chord ratio. Construction is of the multi-spar fail-safe type, with the spaces between being utilized for fuel storage. Sealants at points of skin/rib/spar contact serve to create the fuel storage cells. Leading edge sweep angle is 52.629-deg. and the trailing edge forward sweep angle is approx. 10-deg. The wing skin, over much of its surface, is corrugated in order to assist

in the displacement of forces created by heat-generated expansion and contraction. The wing leading edges have a decided conical camber that has been aerodynamically optimized through several thousand hours of wind tunnel testing. Additionally, the leading edges are designed to physically compensate for expansion and contraction brought on by temperature variations. The outer wings and outer half of each engine nacelle are hinged and fold upward for access to the engines. Conventional hydraulically-actuated elevons with 35-deg. of up travel and 20-deg. of down travel serve as the only pitch and roll control surfaces on the aircraft and make up the trailing edge segments of both wings.

The aircraft, in operational service, is painted black over-all (and not dark blue as has been quoted by some sources). The exact paint type and F.S. number remain classified, due primarily to the paint's chemistry and its contribution to the "stealth" characteristics of the airplane. The paint is, in fact, called "iron ball" due to minute iron balls used in its pigmentation. These dissipate electro-magnetically-generated energy and effectively lower the radar signature of the aircraft. The paint is also optimized for high heat emissivity and actually radiates significantly more friction-generated heat than it absorbs at crusing speeds of Mach 3.

The engine nacelles are integral with the wings and are supported by conventional ring-type carry through structures. Mounted atop each engine nacelle is a large slab-type all-moving vertical tail surface. These are canted inward some 15-deg. primarily to take advantage of the chine vortex in such a way that the directional stability improves as the angle of attack increases (each movable part of the vertical surface has a 20-deg. travel to left or right). The cant also contributes to a lowering of the aircraft radar signature.

The YF-12A and SR-71B/C variants are equipped with nacelle-mounted ventral fins to correct for a loss of directional stability resulting from the loss of chine area in the former and an increase in forward fuselage area in the latter. Additionally, the YF-12A is equipped with a hydraulically actuated folding ventral fin for increased directional stability.

The tricycle landing gear consist of two unorthodox three-wheel mains and a conventional steerable twin-wheel nose unit. The mains retract inward toward the fuselage centerline into special gear wells that are cooled for tire preservation. Nitrogen gas is used for inflation to minimize expansion and contraction and to prevent fires. The actual high-pressure main gear tires, by B.F. Goodrich, are impregnated with powdered aluminum to improve their heat reflecting ability. The nose gear retracts forward and the tires, also by B.F. Goodrich, are not aluminum powder impregnated. The mains are equipped with a rudimentary anti-skid system and there is an immense drag chute carried and deployed from a large compartment on the top side of the fuselage empennage. The landing gear retraction system is totally hydraulic as are all control surfaces and the engine intake spike actuators.

Standard instrumentation and navigation equipment includes an astro-inertial navigation system (with tracker mounted behind the rear cockpit on the SR-71 and ahead of the front cockpit on the A-12), an air data computer, an automatic flight control system (consisting of a three-axis stability augmentation system capable of responding to an asymetric thrust situation at Mach 3 in less than .15 seconds, an autopilot, and a Mach trim system), a control system for governing automatically the variable inlets, fuel supply and variable area exhaust nozzles, a triple display indicator giving digital readout of Mach number, altitude, and airspeed (in knots), and a conventional flight director system (modified to present angle of attack information during cruise on the glideslope portion of the attitude display indicator).

The reconnaissance sensor system complement remains extremely sensitive technologically and little information has been released concerning it. In general, it consists of a great variety of photo-optical and electromagnetic sensors mounted in approximately five major chine (along either side of the primary fuselage tube) and nose bays. Included in the aircraft sensor system complement are LOROP cameras of 66" (or more) focal length developed by ITEK and General Dynamics (with resolution capabilities of approximately 3′ at 100 miles), general battlefield surveillance systems consisting of panoramic and short fixed focal length cameras, infra-red and laser activated units, and various magnetic tape and disc-type receivers capable of sensing, interpreting, and recording a virtually infinite number of frequencies in the non-optical range. Additionally, there are operational systems related to any one or all of the above that provide for real-time information and data transmittal, via satellite data-link, to any spot on the globe. The aircraft also carries an exceptionally powerful countermeasures system that has both passive and active capabilities. Like most systems of this type, it prioritizes threats based primarily on their proximity, and actuates countermeasures automatically based on this prioritization.

The SR-71A, at a cruising speed of Mach 3, is capable of surveying 100,000 square miles in one hour from an altitude of 80,000′. A weapons delivery capability for the SR-71A has been alluded to.

One A-12 advanced development study has recently come to light in the form of the R-12. A proposed bomber configuration that would have accommodated several weapons in large fuselage bays, the R-12 differed from the A-12 in having a flat bottom like the YF-12A and a chined nose with infra-red sensors recessed into the forward chine edges. This configuration could carry up to 3 weapons with the fourth bay being reserved for dedicated defensive and offensive avionics.

POWERPLANT:

Perhaps the most complex aspect of the basic *Blackbird* program design concept is that of its propulsion system. Integrating the awesome capabilities of the Pratt & Whitney JT11D-20B (military designation, J58) turbo-ramjet powerplant into an aerodynamically advanced chined-delta airframe, the *Blackbird* family is the first to utilize this propulsion system operationally. All three basic configurations utilize the JT11D-20B turbo-ramjet which has a sea level afterburning thrust rating of 32,500 lbs.

This powerplant is unique among operational jet engines in that it has a very high capacity by-pass duct system which routes fourth-stage compressor section air to the afterburner for augmentation, cooling, and an increase in the compressor section stall margin. Many prototype and pre-production JT11D configurations were tested by P&W prior to the installation and use of the type in the A-12/YF-12/SR-71 family.

The powerplant came to life as a U.S. Navy-sponsored program calling for an engine capable of sustained operation in the Mach 2.5 to 3.0 range. Initially, ram compression at supersonic speeds was expected to augment the compressor's moderate pressure ratio and the afterburner was to be a conventional convergent-divergent unit giving the engine a maximum thrust rating at sea level of 45,000 lbs.

The core unit is a conventional 9-stage axial compressor, annular combustor, 2-stage turbine type turbojet. The air intake casing consists of 20 circumferential openings for auxiliary air intake. Twenty radial struts support the front main bearing. The compressor is a 2-piece barrel type with a steel casing. The front section has 4 rows of fixed stator blades, with 20 circumferential slots with sliding valves and 3 actuators around the rear of the casing for blow off air and ground operation. The rear section has 5 rows of fixed stator blades. The rotor is supported in ball and roller bearings and flexibly connected to the turbine drive shaft. The pressure ratio of the compressor is 6 to 1 and the air mass flow is 450 lbs/sec/static.

The combustor is an annular type with a 1-piece outer shell. There are 8 duplex fuel burners. The turbine is of the steel casing type with hollow nozzle vanes. There are two turbine wheels mounted on the drive shaft supported in ball and roller bearings. The basic fuel control system consists of two centrifugal type fuel pumps with an AiResearch flow control unit. The lubrication system is of the return type with a gear pump, a fuel-cooled oil cooler, and a saddle storage tank.

Accessories include a pneumatic or fuel-air combustion starter, a Bendix-Scintilla or G.L.A. high energy ignition system, and two igniter plugs. Core diameter is 50", core length is 144", and total frontal area is 13.6 sq. ′. Core section weight is 6,000 lbs., and core section normal fuel consumption is approximately .70 lb/lbt/hr.

As installed in the A-12/YF-12/SR-71 family the engine discharges through an ejector nozzle which is part of the airframe and is of purely aerodynamic design. The primary nozzle is a ring of blow-in doors which provide tertiary air to fill in the ejector at Mach numbers below 1.1. This tertiary air is provided by suck-in doors around the nacelle, augmented by the cowl (shock trap) bleed and aft by-pass bleed. The main ejector is supported downstream on streamlined struts and a ring of Rene 41 steel alloy, on which are hinged free-floating trailing edge flaps of Hastelloy X. These open progressively between Mach .9 and Mach 2.4 to provide a divergent shroud around the primary nozzle and the secondary stream. At low Mach numbers the ejector adds nothing to the engine thrust; at Mach 2.2 it provides 14% of the total propulsive thrust; and at Mach 3.2 and above, it is contributing some 28.4%. The powerplant nacelle also incorporates suck-in doors, to provide tertiary flow, and secondary by-pass doors around the plane of the engine inlet face.

The air intakes are the most complex components in the propulsion system. Each powerplant is fed by a circular air inlet with an electro-hydraulically actuated translating intake spike. At low Mach numbers the spike is locked fully forward where it diverts or spills excess airflow ahead of the inlet and provides satisfactory throat area at the inlet lip. At 30,000′ altitude the spike is unlocked and starts to translate aft at Mach 1.6. The inlet should have self-started by this time, although this can be delayed until as late as Mach 2.1. As the spike retracts, the throat moves aft to the station of the cowl shock trap bleed, where the cowl boundary layer is bled off through 32 fixed solid-wall axial ducts. The spike boundary layer is also bled off and dumped overboard through a multiply-slotted section of the centerbody. Rearward translation of the spike closes total throat area by some 54%, compared to the Mach 1 setting, but increases the area of the captured stream tube by 112%.

Engine operation is also critically dependent upon the forward by-pass doors, which are a series of large apertures in a broad band in the outer cowl wall just downstream of the throat. Rotation of this band progressively uncovers matching apertures in the duct itself, allowing airflow to escape overboard through louvers. The doors are open on the ground, but rotate to the closed position upon retraction of the landing gear. At speeds above Mach 1.4 the by-pass may modulate as required to maintain a scheduled pressure ratio between selected pitot and static pressures.

The complete inlet system is controlled by Hamilton Standard fail-safe powered systems, with manual emergency operation, with computer control according to sensed flight Mach number, angle of attack, angle of sideslip, and normal acceleration, thus providing an automatic restart cycle to recover from inlet unstarts.

Variation in forward by-pass can exert an enormous influence on aircraft drag, especially noticeable as a pronounced yaw if one by-pass modulates while the other remains shut. When operating perfectly, the inlet system generates a pressure ratio of more than 40 to 1 at cruising Mach number. At low speeds the inlet generates little forward thrust; at Mach 2.2 it generates only 13% of the total propulsive thrust, whereas at about Mach 3.2 it generates 54%. The engine, at Mach 3.2, is generating only 17.6% of the total thrust.

Fuel consumption at a cruising Mach number of 3.2 is approximately 8,000 gallons per hour. The fuel type is JP-7 which has an extremely high vapor temperature and concommitantly, a very high flash point. The latter, in fact, is cause for use of TEB (tetraethyl borane) during the starting procedure—this effectively lowering the flash point and permitting easier ignition. TEB is also used during afterburner ignition as the same flash point and temperature problems remain.

During cruising flight at Mach 3.2, the engine compressor inlet temperature operates steady-state at 800-deg. F., the turbine inlet temperature runs steady-state at 2,000-deg. F., the fuel inlet temperature runs steady-state at 300-deg. F., and the oil inlet temperature runs steady-state at 550-deg. F. The engine thrust-to-weight ratio at cruise stabilizes at approximately 5.2 to 1.

SERIAL NUMBERS/ COMMENTS

A-12/F-12 Comments

60-6924 Prototype a/c. Last known disposition (5-83) was storage in Lockheed's facility at Palmdale. Aircraft used as testbed by Lockheed at Groom Lake, throughout its career.

60-6925 Last known disposition (5-83) was storage in Lockheed's facility at Palmdale.

60-6926 Tested at Groom Lake and thought lost on 5-24-63 (inverted flat spin in a thunderstorm) during test program. The pilot survived.

60-6927 Two-seat modification nicknamed "Titanium Goose." Last known disposition (10-77) was storage in Lockheed's facility at Palmdale.

60-6928 Tested at Groom Lake and lost 1-5-67, during test program. The pilot did not survive.

60-6929 Tested at Groom Lake and lost in 1965/1966 time frame during test program. The pilot survived.

60-6930 Last known disposition (5-83) was storage in Lockheed's facility at Palmdale.

60-6931 Last known disposition (5-83) was storage in Lockheed's facility at Palmdale.

60-6932 Tested at Groom Lake and lost on 6-5-68, following departure from Kadena AB. This was the last A-12 flight out of Kadena. The pilot did not survive.

60-6933 Last known disposition (5-83) was storage in Lockheed's facility at Palmdale.

60-6934 Prototype YF-12A. Initially tested at Groom Lake, later at Edwards AFB. Seriously damaged during landing at Edwards. Rear half later utilized to construct SR-71C (64-17981).

60-6935 Second YF-12A, initially tested at Groom Lake, later Edwards AFB. Retired from flight test 11-7-79 and flown to A.F. Museum at Wright-Patterson AFB, Ohio, where it is permanently displayed.

60-6936 Third YF-12A, initially tested at Groom Lake, later Edwards AFB. Lost in accident at Edwards, 6-24-71. Used during speed and altitude record flights in May of 1965.

60-6937 Last known disposition (5-83) was storage in Lockheed's facility at Palmdale.

60-6938 Last known disposition (5-83) was storage in Lockheed's facility at Palmdale.

60-6939 Tested at Groom Lake and lost during 1964/1965 time period. The pilot survived.

60-6940 Tested at Groom Lake and last known to be in storage in Lockheed's facility at Palmdale. Aircraft is one of two converted for D-21 transport.

60-6941 Second aircraft converted for D-21 transport. Tested at Groom Lake and lost on 7-30-66 during test program.

60-6942 Serial number assigned, but aircraft was not built.

60-6943 Serial number assigned, but aircraft was not built.

60-6944 Serial number assigned, but aircraft was not built.

60-6945 Serial number assigned, but aircraft was not built.

60-6946 Serial number assigned, but aircraft was not built.

60-6947 Serial number assigned, but aircraft was not built.

60-6948 Serial number assigned, but aircraft was not built.

SR-71

64-17950 Operational with 9th SRW until 1969. Lost on 4-11-69 following takeoff accident.

64-17951 This aircraft became the NASA YF-12C and was allocated the fictitious serial number of 60-6937 (the A-12 serial number allocated to aircraft Lockheed Build #131). It was de-militarized for NASA use and is somewhat lighter and higher-performing than stock SR-71A configurations. It is now in storage at the Lockheed Palmdale facility.

64-17952 Was operational with 9th SRW until it was lost near Tucumcary, New Mexico on 1-25-66. This was the first SR-71 accident. The pilot survived but the RSO did not.

64-17953 Lost during SR-71 test program. Possibly accident on 1-10-67 over Beatty, Nevada.

64-17954 Thought to have been lost over Roy, New Mexico on 2-9-66.

64-17955 Known to have operated out of Eglin AFB. Last known to be operating with the 9th SRW/Det. 5 out of Lockheed Palmdale.

64-17956 SR-71B conversion from SR-71A. Aircraft still in use as trainer at Beale AFB.

64-17957 Stated to be the first operational SAC SR-71A and the first aircraft delivered to the (then) 4200th SRW at Beale AFB. This serial number has been reported in official sources as being allocated to an SR-71B. This aircraft was lost on approach to Beale AFB on 1-12-68

64-17958 Was last known to be operational with the 9th SRW.

64-17959 Was last known to be operational with the 9th SRW.

64-17960 Was last known to be operational with the 9th SRW.

64-17961 Was last known to be operational with the 9th SRW.

64-17962 Was last known to be operational with the 9th SRW.

64-17963 Was last known to be operational with the 9th SRW.

64-17964 Was last known to be operational with the 9th SRW.

64-17965 Nothing known, though aircraft is thought to have been the one lost near Lovelock, Nevada on 10-25-67.

64-17966 Nothing known, though the aircraft is thought to have been the one lost near Las Vegas, New Mexico on 4-13-67.

64-17967 Was last known to be operational with the 9th SRW.

64-17968 Was last known to be operational with the 9th SRW.

64-17969 Was last known to be operational with the 9th SRW.

64-17970 Nothing known.

64-17971 Was last known to be operational with the 9th SRW.

64-17972 Was last known to be operational with the 9th SRW. Used during trans-Atlantic speed record flight.

64-17973 Was last known to be operational with the 9th SRW.

64-17974 Was last known to be operational with the 9th SRW.

64-17975 Was last known to be operational with the 9th SRW.

64-17976 Was last known to be operational with the 9th SRW.

64-17977 Nothing known.

64-17978 Lost during accident at Kadena AB in May of 1973.

64-17979 Was last known to be operational with the 9th SRW.

64-17980 Was last known to be operational with the 9th SRW.

64-17981 Only SR-71C. Hybrid aircraft from salvaged parts of YF-12A, 60-6934 (rear half) and a functional engineering mock-up forward fuselage.

64-17982 Serial number assigned, but aircraft was not built.

64-17983 Serial number assigned, but aircraft was not built.

64-17984 Serial number assigned, but aircraft was not built.

64-17985 Serial number assigned, but aircraft was not built.

SPECIFICATIONS:

	A-12	YF-12A	SR-71A
Fuselage length	102'0"	101'8"	107'5"
Fuselage diameter	5'4"	5'4"	5'4"
Wingspan	55'7"	55'7"	55'7"
Wing area	1,795 sq.'	1,795 sq.'	1,795 sq.'
Wing aspect ratio	1.939	1.939	1.939
Wing root chord	60'10"	60'10"	60'10"
Dihedral	0 deg	0 deg.	0 deg.
Incidence	1.20 deg.	1.20 deg.	1.20 deg.
Mean aerodynamic chord at W.S. 118	40'6"	40'6"	40'6"
Height	18'3"	18'3"	18'6"
Inboard elevon area	39 sq.'	39 sq.'	39 sq.'
Outboard elevon area	52.5 sq.'	52.5 sq.'	52.5 sq.'
Vertical tail area	150.75 sq.'	150.75 sq.'	150.75 sq.'
Vertical tail aspect ratio	.778	.778	.778
Vertical tail taper ratio	.392	.392	.392
Vertical tail root chord	20'0"	20'0"	20'0"
Tip chord	7'10"	7'10"	7'10"
Vertical tail sweep angle	32.207 deg.	32.207 deg.	32.207 deg.
Mean aerodynamic chord	14'10"	14'10"	14'10"
Movable vertical tail area	70.2 sq.'	70.2 sq.'	70.2 sq.'
YF-12A foldable ventral fin area		149.6 sq.'	
YF-12A nacelle ventral fin area		22 sq.'	
Wheel track	16'8"	16'8"	16'8"
Wheelbase	37'10"	37'10"	37'10"
Empty weight	38,000 lbs.	?	60,000 lbs.
Gross weight	140,000 lbs.	140,000 lbs.	172,000 lbs.

PERFORMANCE:

	A-12	YF-12A	SR-71A
Max. speed at 80,000'	Mach 3.35 (2,275 mph)	Mach 3.35 (2,275 mph)	Mach 3.35 (2,275 mph)
Operational ceiling	95,000'	85,000' +	85,500'
Max. unrefueled range at M.3	2,500 mi.	2,500 mi.	3,250 mi.

AVAILABLE SCALE MODELS AND DECALS:

Several kit manufacturers are either producing, or soon to produce kits of the enigmatic *Blackbird*. Among the more important are Revell's 1/72nd scale SR-71A and YF-12A kits (the former of which is still apparently in production under the auspices of Revell Mexico), and Hasegawa's 1/72nd SR-71A. The Testor Corporation is releasing a quarter-scale SR-71A/B at this time and the kit will come complete with instructions for conversion to A-12 standards. A quarter-scale YF-12A is to follow. Additionally, two companies have now issued vacu-form models of the little-known D-21. The first of these, produced by Frank Models/Air Models of Europe, is a 1/72nd effort; the second, produced by Eagle's Talon, is a 1/48th effort and comes complete with a pylon, nose and tail fairings, drawings of the transport cart, and a ten-page history of the D-21 program. The only decal sheet currently available is Microscale's 72-110 which also includes decals for an RF-101C.

USAF

Only photo released to date depicting an A-12, 60-6940, carrying a D-21 drone.

YF-12 Overview

NASA

Front view of YF-12A, 60-6935, illustrating reconfigured chine.

Lockheed-California Co.

First YF-12A, 60-6934, at Groom Lake test facility.

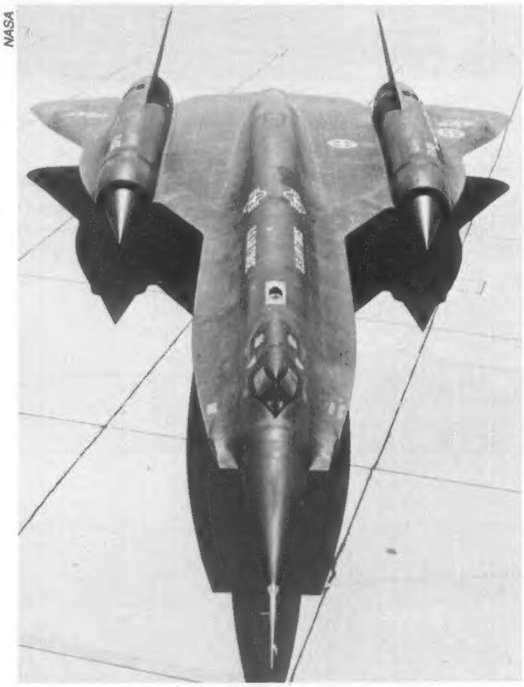
USAF

YF-12A, 60-6934, at Edwards AFB during weapon tests (note weapons bay doors).

NASA

YF-12A, 60-6935, during NASA flight test program (note photo markings).

NASA



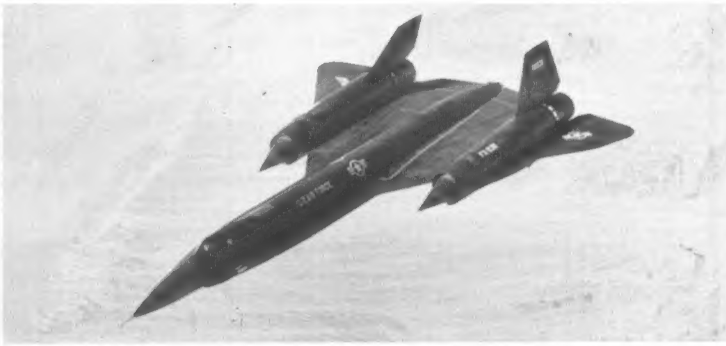
Overhead view of YF-12A, 60-6935.

USAF

YF-12A, 60-3935, landing during the course of the Air Force flight test program at Edwards AFB.

Lockheed-California Co.

YF-12A, 60-6935, taking off on test mission from Edwards AFB.

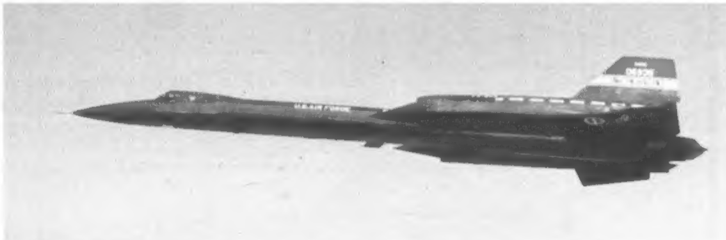


Lockheed-California Co.

Inflight view of YF-12A, 60-6936, during test mission from Edwards AFB.

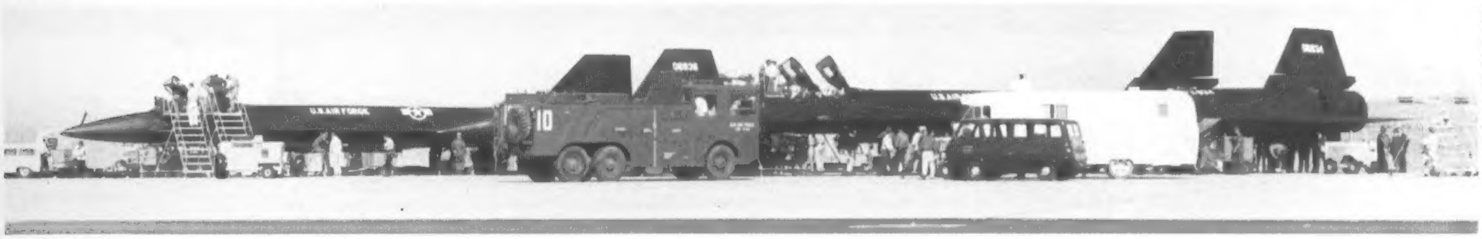
NASA

YF-12A, 60-6935, shown during test flight under the auspices of the NASA.



NASA

Another inflight view of YF-12A, 60-6935, during the NASA test program.



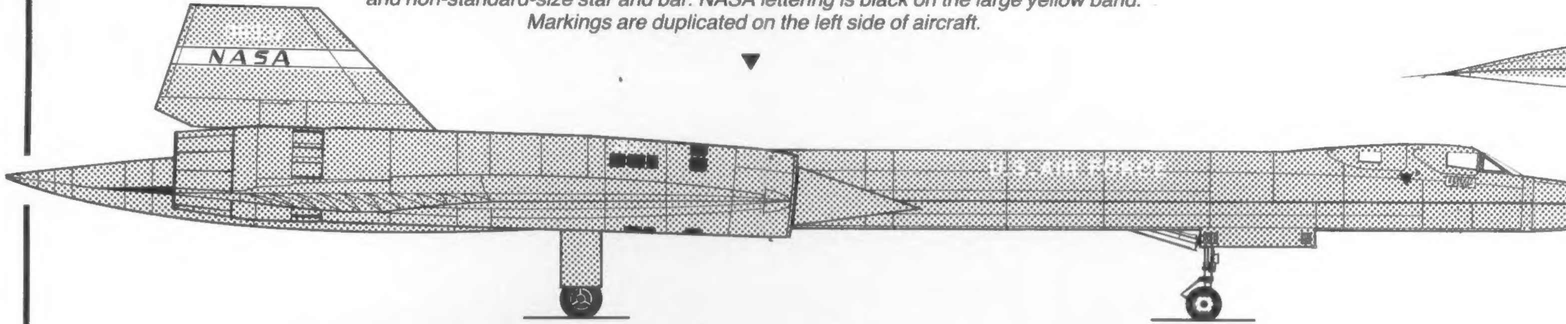
Lockheed-California Co.

Two of the three YF-12A's, 60-6934 and 60-6936, during the course of their weapon test program at Edwards AFB.

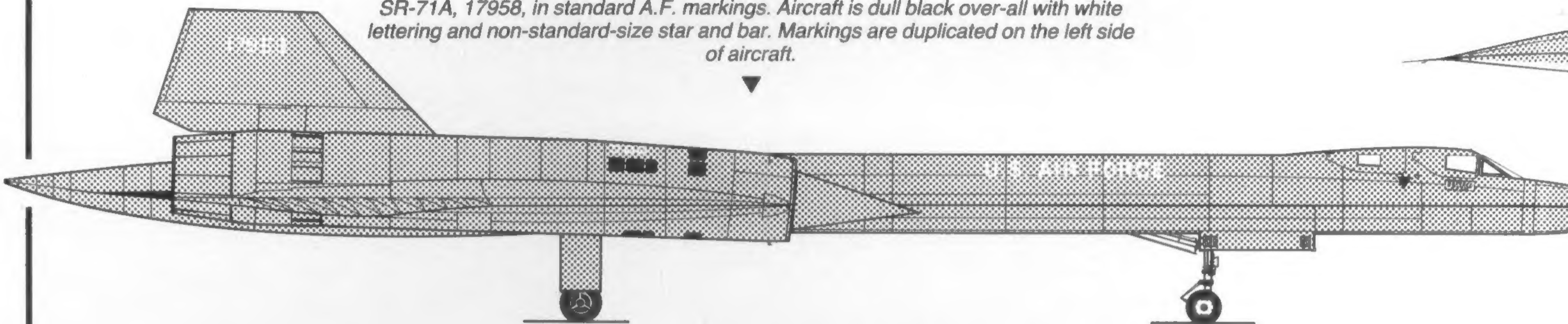
Lockheed-California Co.

YF-12A, 60-6936, being prepared for a mission during the flight test program at Edwards AFB.

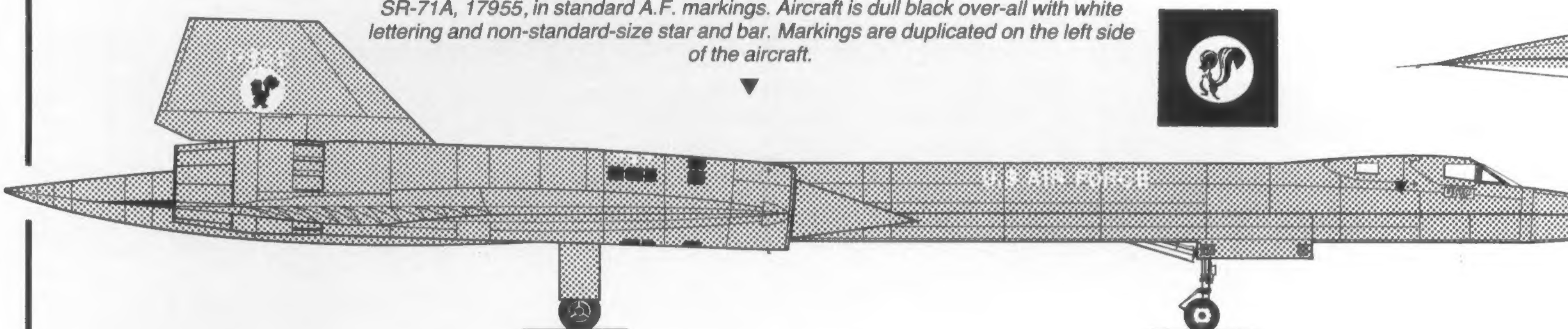
YF-12C, 60-6937, in NASA markings. Aircraft is dull black over-all with white lettering and non-standard-size star and bar. NASA lettering is black on the large yellow band. Markings are duplicated on the left side of aircraft.



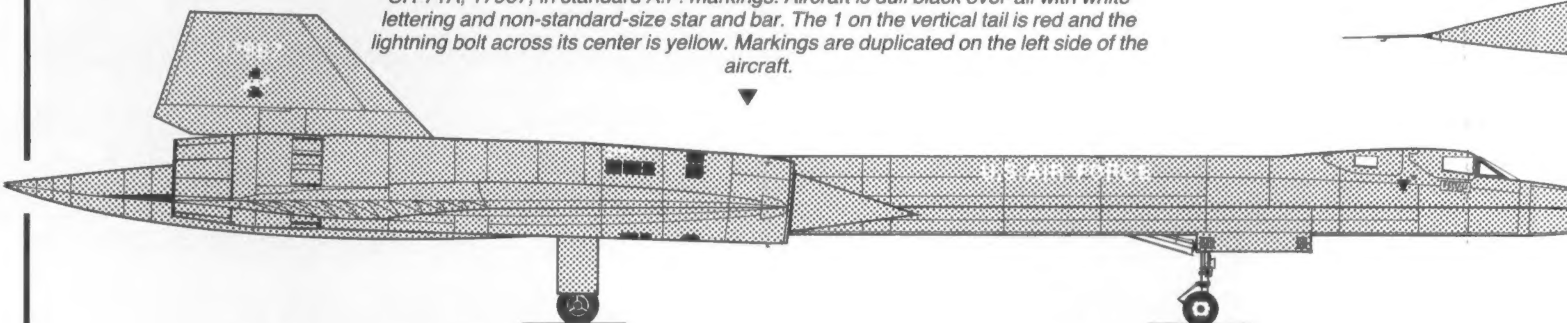
SR-71A, 17958, in standard A.F. markings. Aircraft is dull black over-all with white lettering and non-standard-size star and bar. Markings are duplicated on the left side of aircraft.



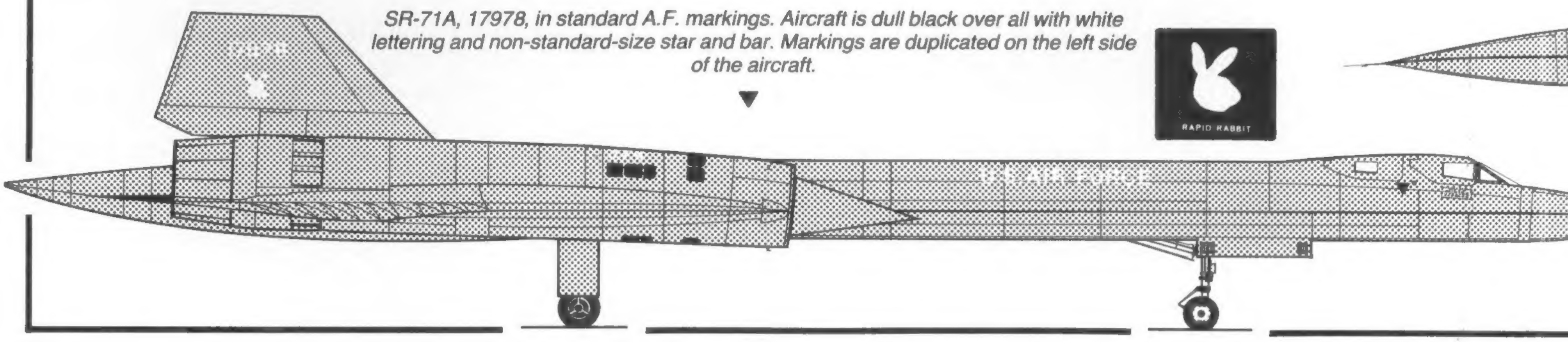
SR-71A, 17955, in standard A.F. markings. Aircraft is dull black over-all with white lettering and non-standard-size star and bar. Markings are duplicated on the left side of the aircraft.



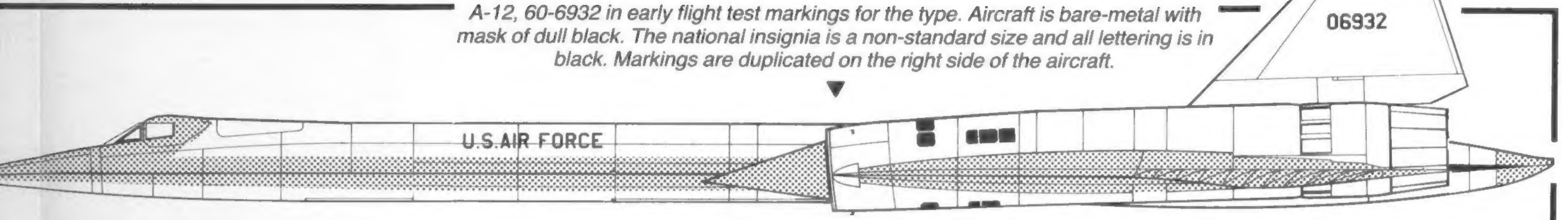
SR-71A, 17967, in standard A.F. markings. Aircraft is dull black over-all with white lettering and non-standard-size star and bar. The 1 on the vertical tail is red and the lightning bolt across its center is yellow. Markings are duplicated on the left side of the aircraft.



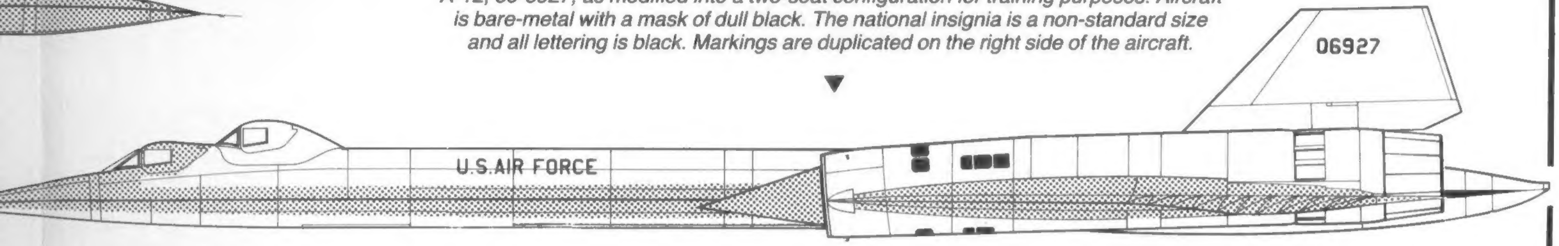
SR-71A, 17978, in standard A.F. markings. Aircraft is dull black over all with white lettering and non-standard-size star and bar. Markings are duplicated on the left side of the aircraft.



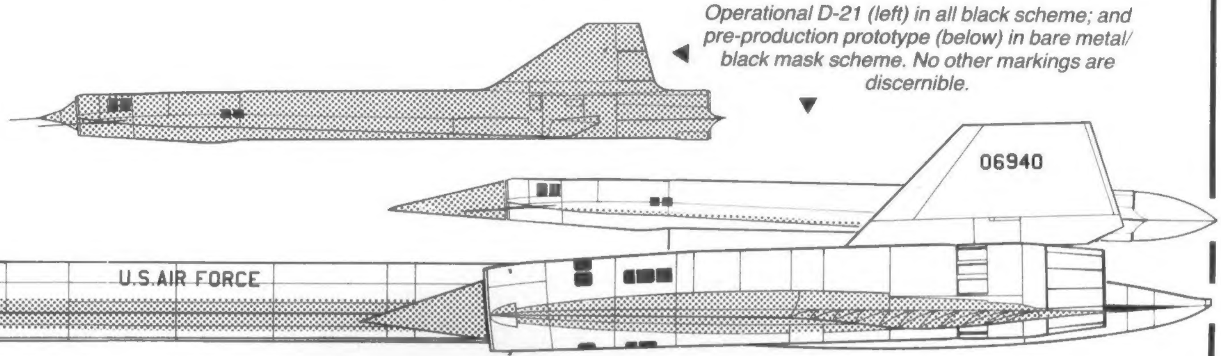
A-12, 60-6932 in early flight test markings for the type. Aircraft is bare-metal with mask of dull black. The national insignia is a non-standard size and all lettering is in black. Markings are duplicated on the right side of the aircraft.



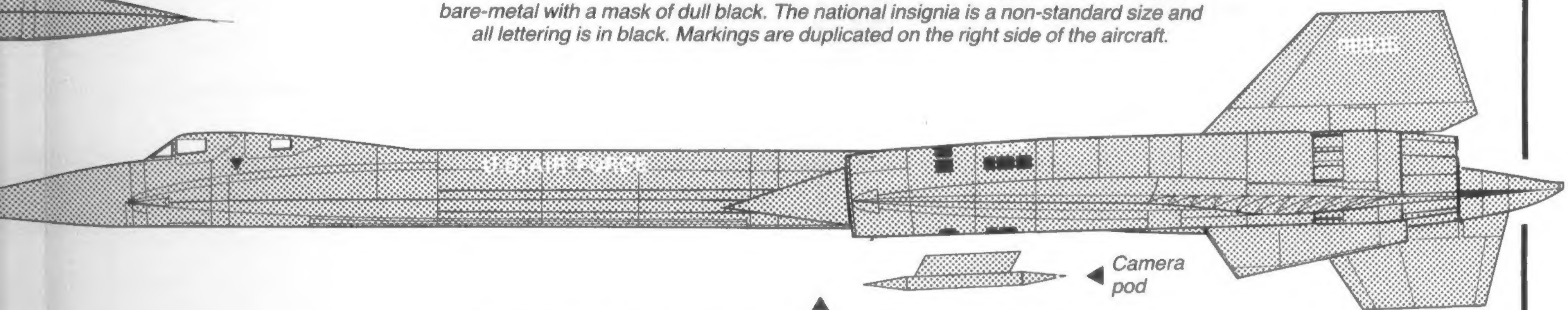
A-12, 60-6927, as modified into a two-seat configuration for training purposes. Aircraft is bare-metal with a mask of dull black. The national insignia is a non-standard size and all lettering is black. Markings are duplicated on the right side of the aircraft.



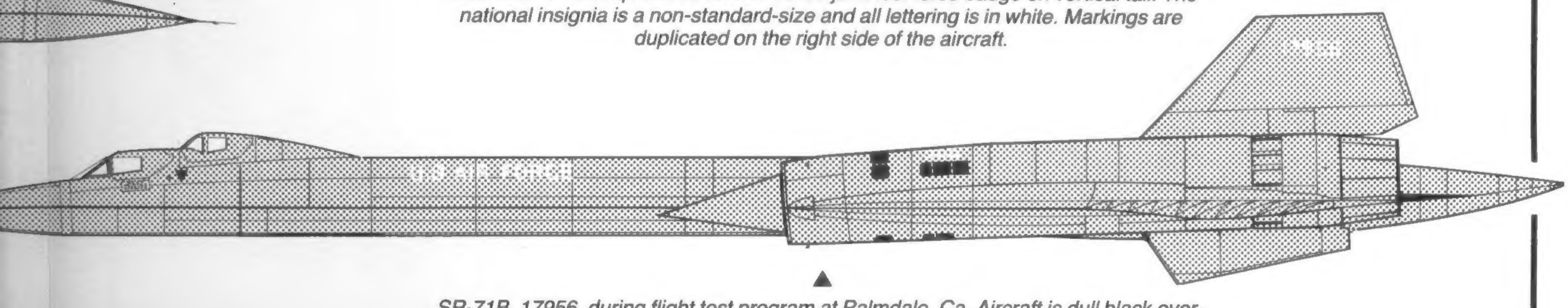
Operational D-21 (left) in all black scheme; and pre-production prototype (below) in bare metal/ black mask scheme. No other markings are discernible.



A-12, 60-6940, as a carrier aircraft for the GTD-21B reconnaissance drone. Aircraft is bare-metal with a mask of dull black. The national insignia is a non-standard size and all lettering is in black. Markings are duplicated on the right side of the aircraft.



YF-12A, 60-6935, in flight test program markings at Edwards AFB. Aircraft is dull black over-all with special NASA/Air Force joint test force badge on vertical tail. The national insignia is a non-standard-size and all lettering is in white. Markings are duplicated on the right side of the aircraft.



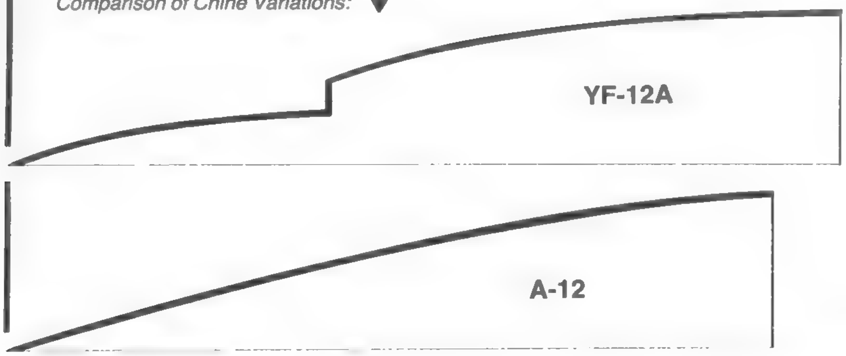
SR-71B, 17956, during flight test program at Palmdale, Ca. Aircraft is dull black over-all with photo markings, serial numbers, and all lettering in white. Markings are duplicated on the right side of the aircraft.

Scale: 1/144

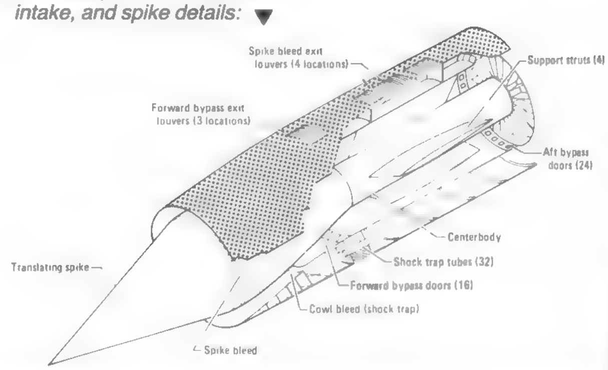
Drawn by Jay Miller

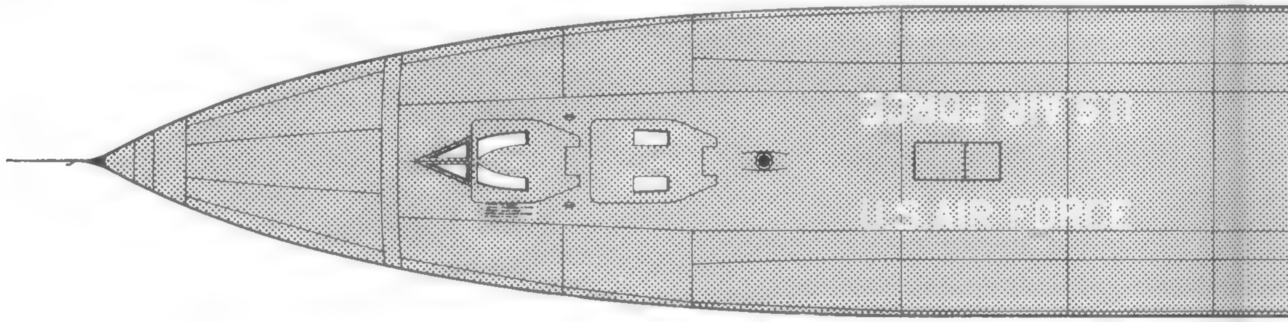
LOCKHEED SR-71A, 64-17974

Comparison of Chine Variations: ▼

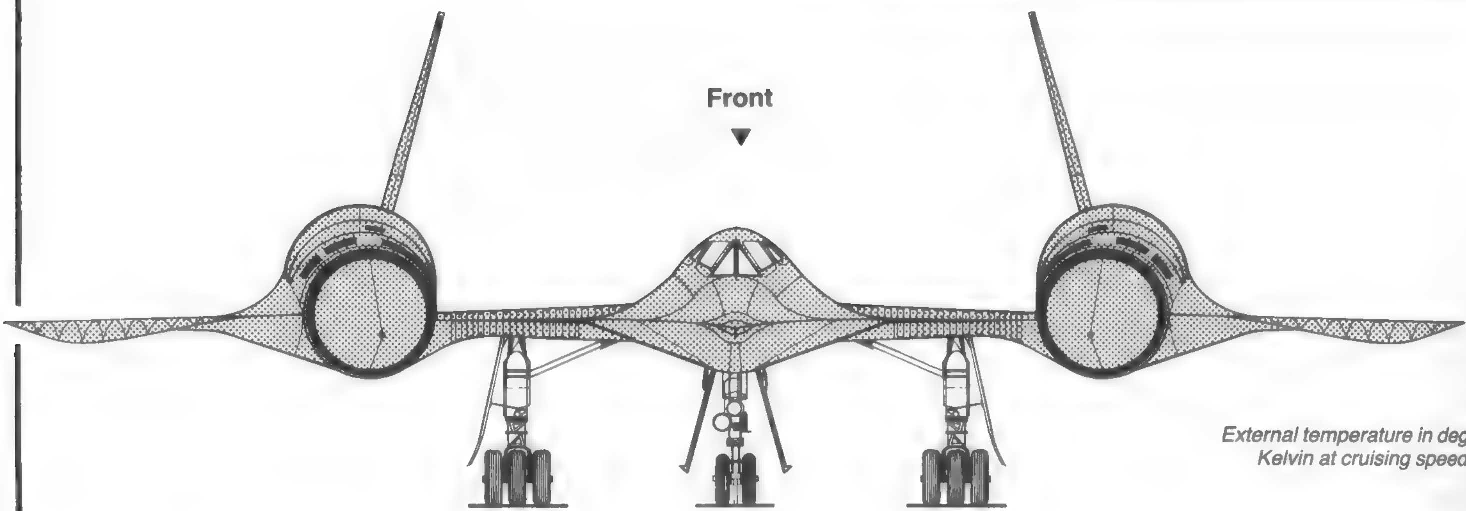


Pratt & Whitney JT11D-20B nacelle, intake, and spike details: ▼



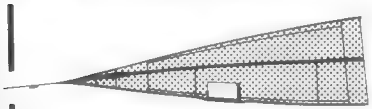


Front ▼

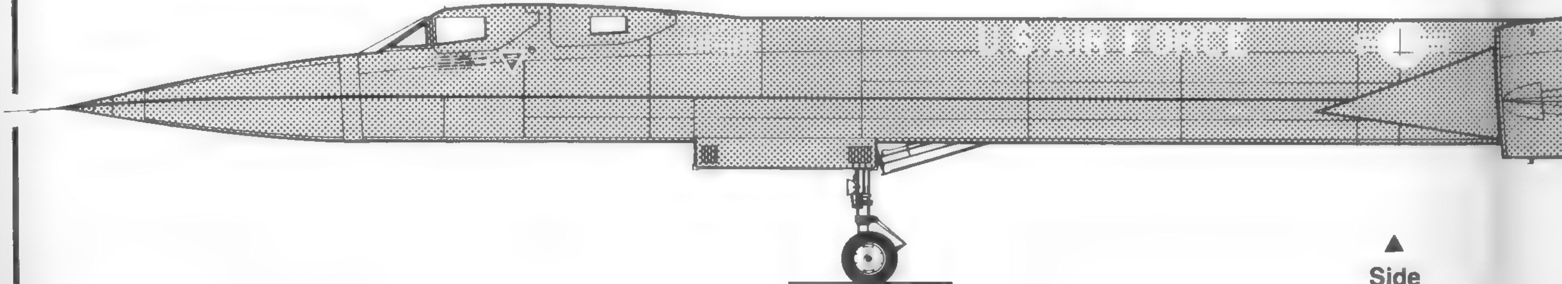


External temperature in degrees Kelvin at cruising speed: ▶

Panoramic Camera Nose: ▼

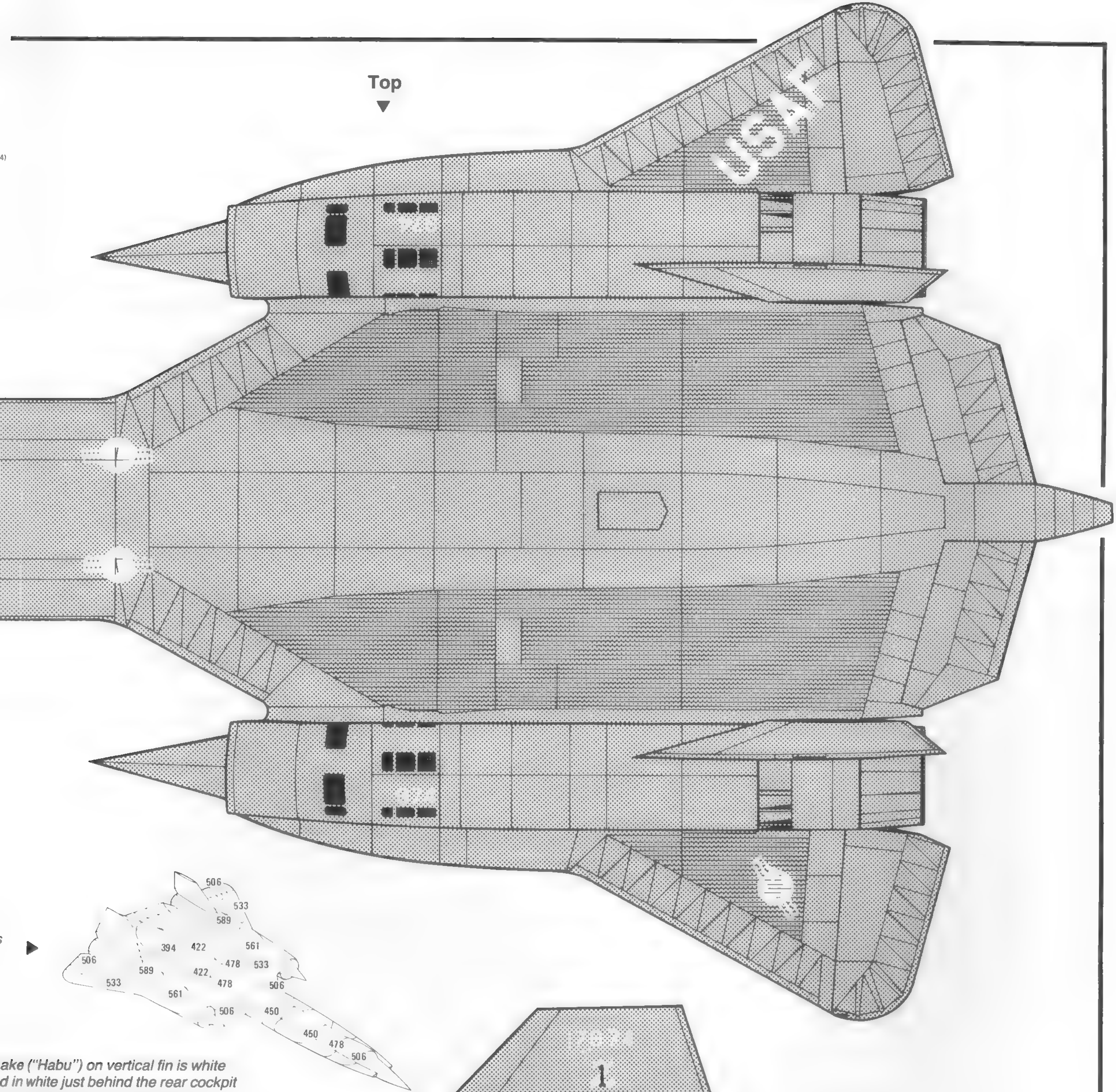


Color scheme information (64-17974): Aircraft is dull black over-all with all lettering and numbers in white. Coiled snake ("Ha with a red 1 painted over it and the words "Ichi Ban" in red underneath. Fifty coiled snake mission symbols are painted in whit on the left side of the fuselage only. The national insignia is of non-standard-size and has a white outline with white star. Only canopy jettison panel underneath the front cockpit is yellow. "No Step" areas are outlined in red.

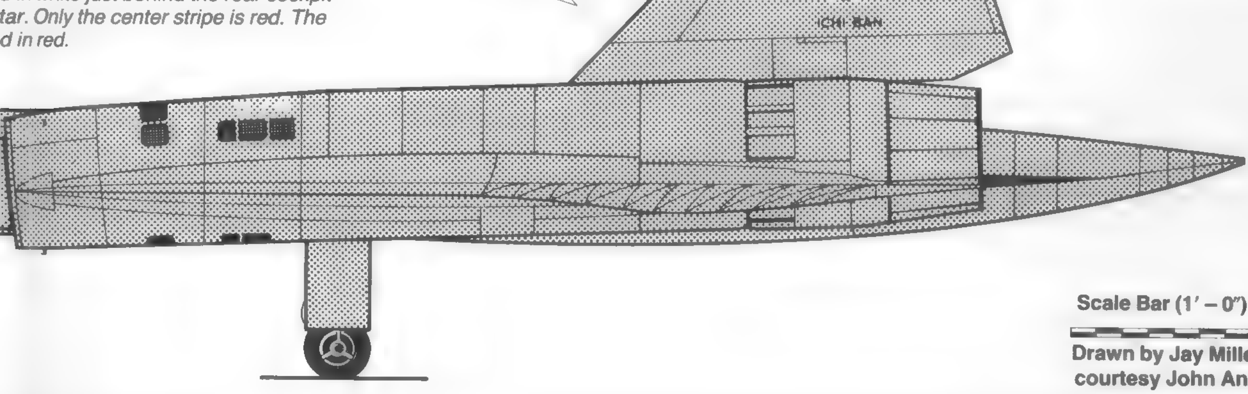


▲ **Side**

Top



ake ("Habu") on vertical fin is white
d in white just behind the rear cockpit
tar. Only the center stripe is red. The
d in red.



Scale Bar (1′ – 0″)

Drawn by Jay Miller w/reference drawings
courtesy John Andrews/Testor Corporation

SR-71 Overview

USAF

Full-pressure suits are worn by SR-71 crew.

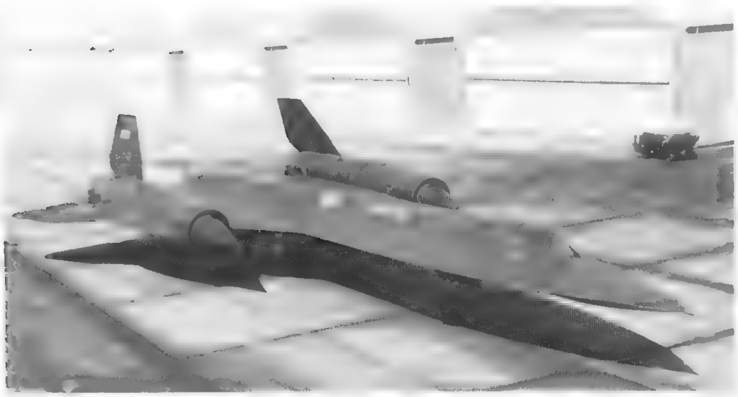
Toshiki Kudo

SR-71A, 17960, during final to Kadena AB, Japan in July of 1978.

Lockheed-California Co

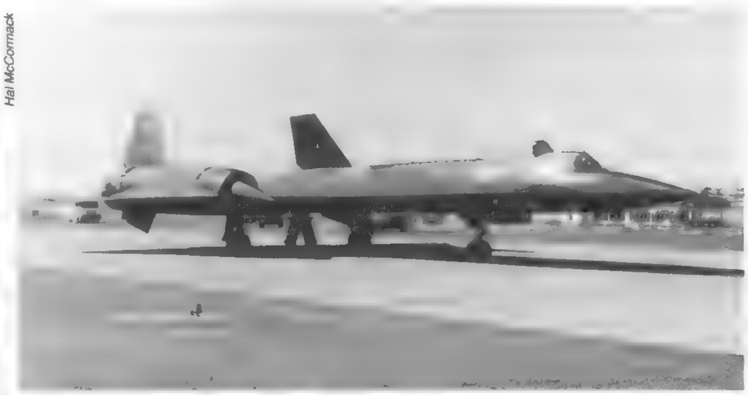
SR-71A, 17964, during test mission from Palmdale, Ca.

Hal McCormack



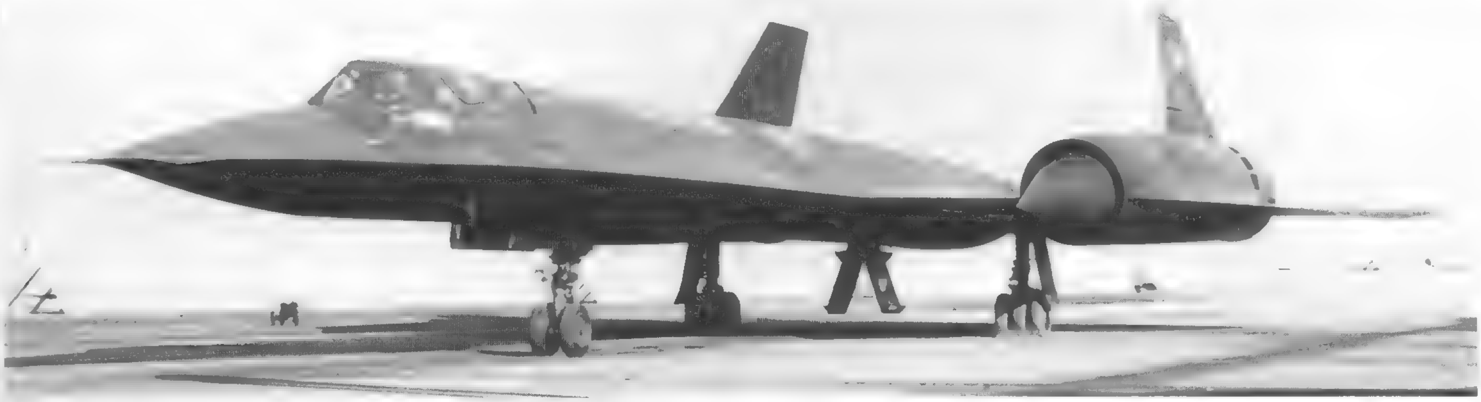
SR-71A, 17971, with RHAW gear in nose chine, is seen at Beale AFB, Ca.

Hal McCormack



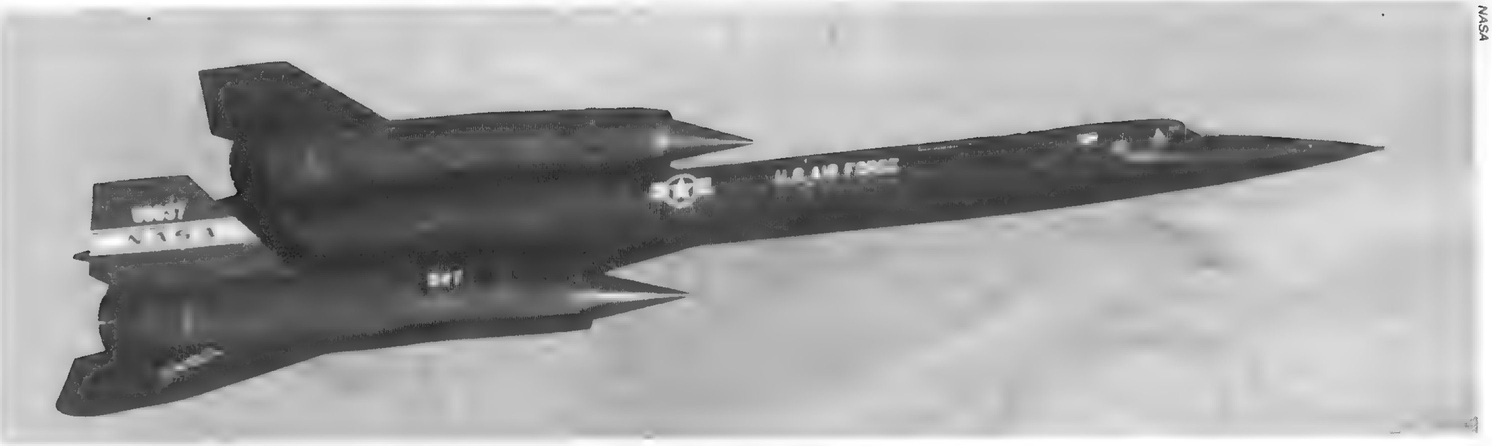
SR-71B, 17956, with elevated rear cockpit for instructor.

Hal McCormack



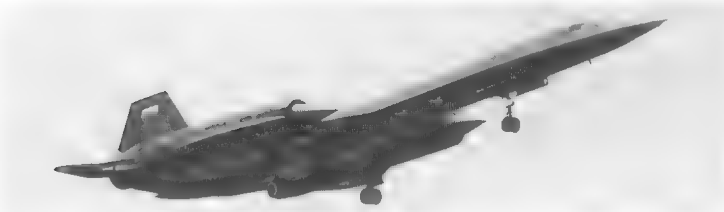
Another view of SR-71A, 17971, at Beale AFB, Ca. Note bumps for RHAW gear on nose chine.

NASA



NASA's YF-12C is actually the number two SR-71. Aircraft has been demilitarized.

Jay Miller/Aerofax, Inc

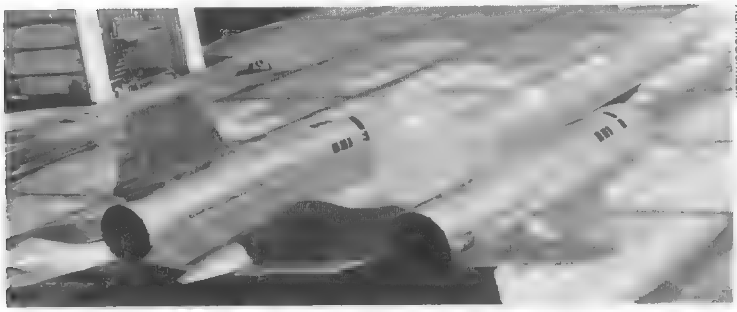


Low-level low-speed pass by SR-71A,17971.

Jay Miller/Aerofax, Inc

SR-71A, 17976, initiates gear retraction following low-speed pass over Randolph AFB, Tx.

Hal McCormack



Rear static view of SR-71A, 17971, at Beale AFB, Ca.

P Bennett via Chris Pocock

SR-71A, 64-17979 at RAF Mildenhall in May of 1979.

Brian Rogers

One of the few extant photos of the two-seat SR-71C, 17981.

Toshiki Kudo

SR-71A, 17976, departs Kadena AB, Japan in July of 1977.

Lockheed-California Co

Following test mission, SR-71B, 17956, taxies in to Lockheed's facility at Palmdale, Ca.

P. Bennett via Chris Pocock

SR-71A, 64-17964 landing at RAF Mildenhall in January of 1981. SR-71's based in England no longer bear visible national markings.

In Detail

Jay Miller/Aerofax, Inc.

Detail of SR-71A nose section reveals slight break in chine at nose cone/fuselage mate.

Hal McCormack

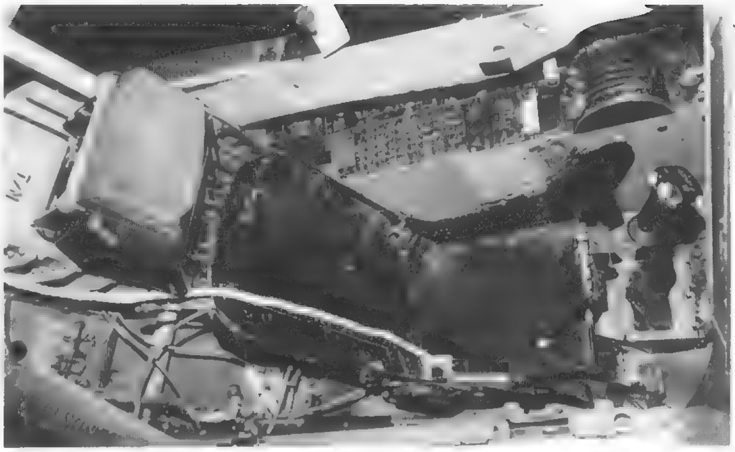
Blended-body configuration of wing/body intersect is readily apparent from this rear view.

Jay Miller/Aerofax, Inc.

SR-71A drag chute is exceptionally large and effective.

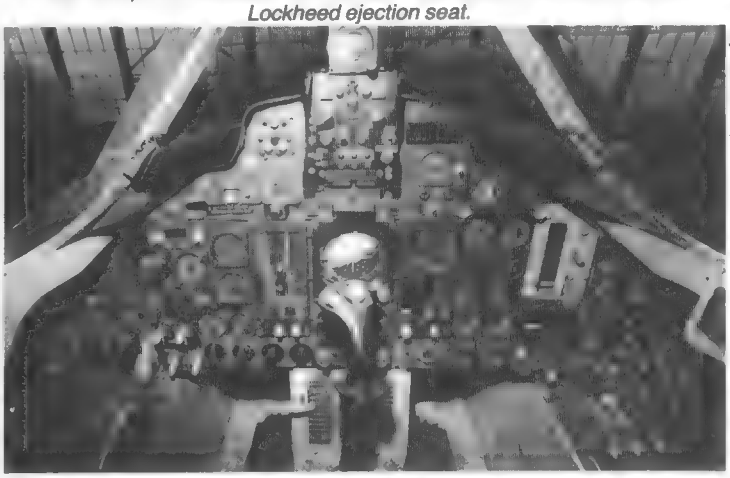
Lockheed-California Co.

Rear cockpit of Lockheed YF-12A, 60-6935, includes unsophisticated Lockheed ejection seat.



Jay Miller/Aerofax, Inc.

Front cockpit and ejection seat of Lockheed YF-12A, 60-6935.

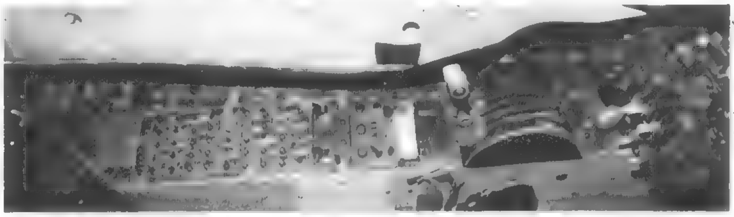


Jay Miller/Aerofax, Inc.

Instrument panel of YF-12A, 60-6935, is fairly conventional in layout.

Jay Miller/Aerofax, Inc.

YF-12A right front cockpit console.



Jay Miller/Aerofax, Inc.

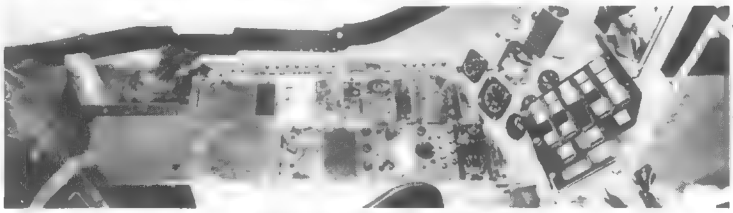
YF-12A left front cockpit console with throttle quadrant.

Jay Miller/Aerofax, Inc.

YF-12A rear cockpit instrument panel.

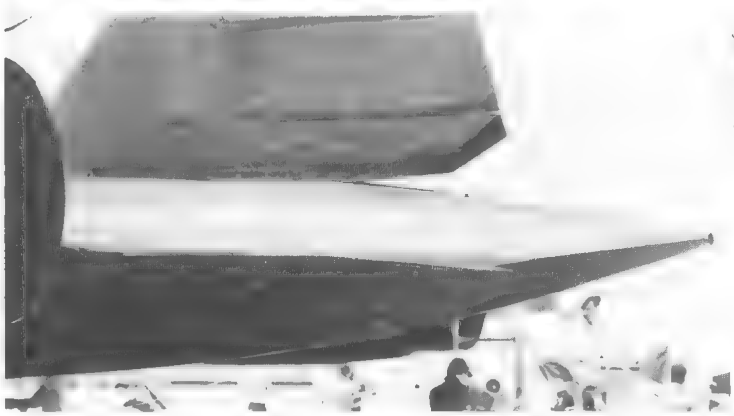
Jay Miller/Aerofax, Inc.

YF-12A rear cockpit right console.



Jay Miller/Aerofax, Inc.

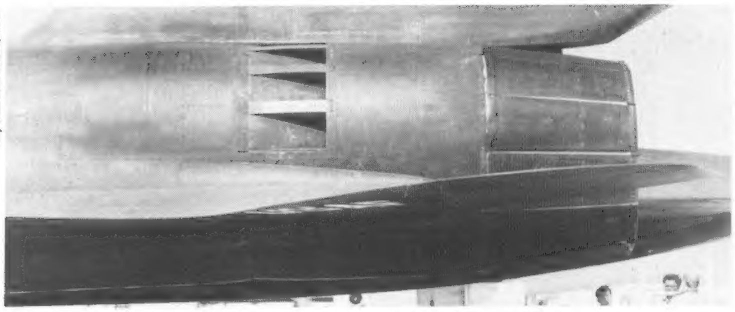
YF-12A rear cockpit left console.



Jay Miller/Aerofax, Inc.

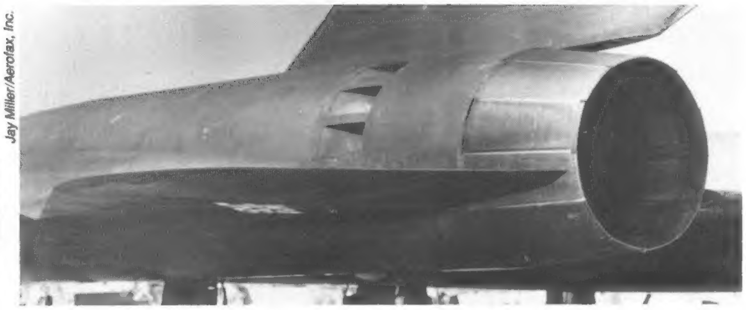
Empennage section of SR-71A, 17976.

Jay Miller/Aerofax, Inc.



Aft engine nacelle section of SR-71A.

Jay Miller/Aerofax, Inc.



Exhaust nozzle and elevon detail of SR-71A.

Jay Miller/Aerofax, Inc.

YF-12A foldable central ventral fin.

Jay Miller/Aerofax, Inc.

YF-12A engine nacelle fixed ventral fin.

Jay Miller/Aerofax, Inc.

YF-12A nose gear and wheel well doors.

Jay Miller/Aerofax, Inc.

SR-71A nose gear and wheel well doors.

Jay Miller/Aerofax, Inc.

Jay Miller/Aerofax, Inc.

Jay Miller/Aerofax, Inc.

Jay Miller/Aerofax, Inc.

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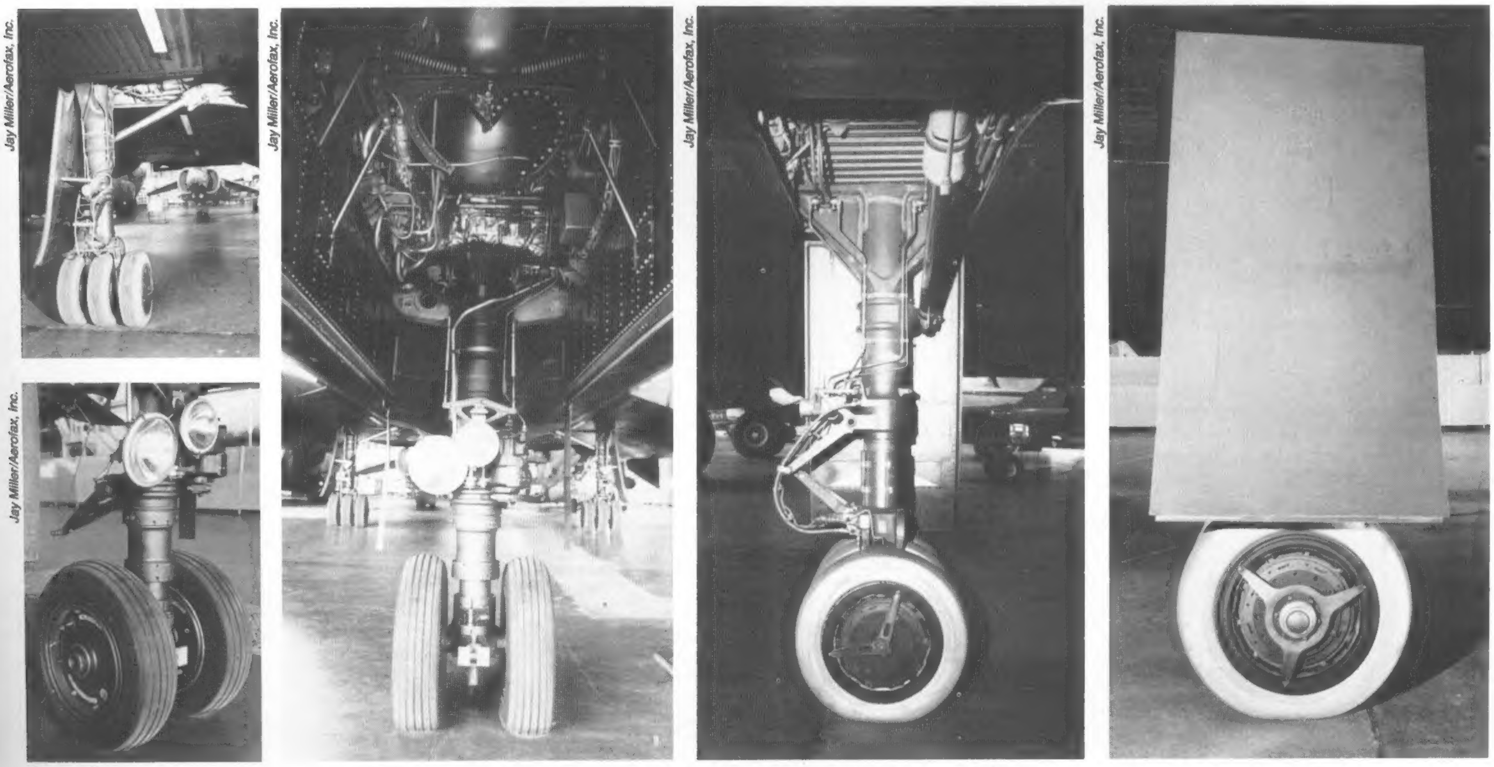


Nose and main landing gear details of YF-12A, 60-6935.

Jim Goodall

Protective skirt surrounds main gear tires.

Jay Miller/Aerofax, Inc.

Inlet spike clearances are minimal.

Jay Miller/Aerofax, Inc.

Vertical tail surface and serial number.

Jay Miller/Aerofax, Inc.

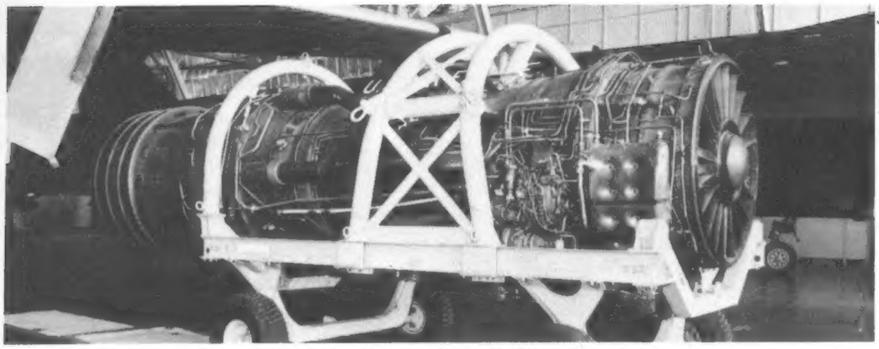
Two-and-a-half percent thickness/chord ratio of wing is readily apparent in this view of starboard section and engine nacelle.

Jay Miller/Aerofax, Inc.

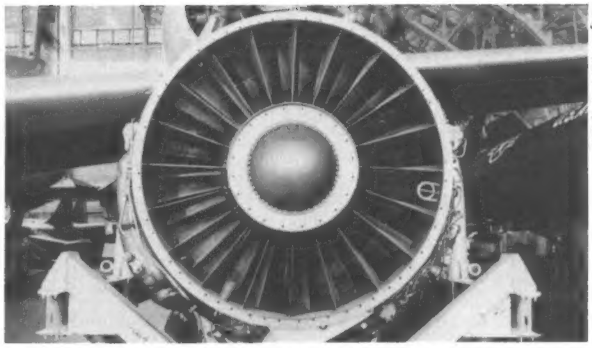
Port engine nacelle and intake spike detail.

Jay Miller/Aerofax, Inc.

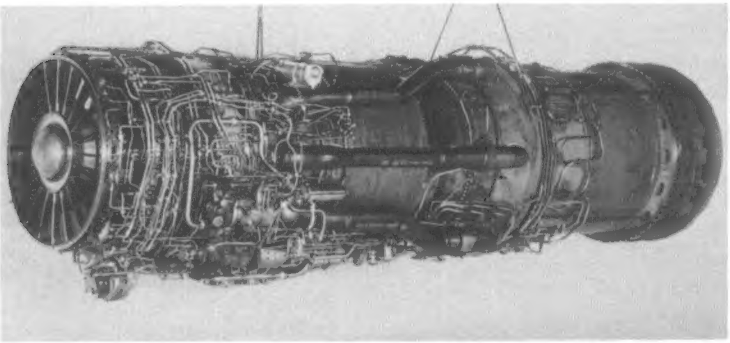
SR-71A engine nacelle is a very complex and subtly unconventional design.


Jay Miller/Aerofax, Inc.

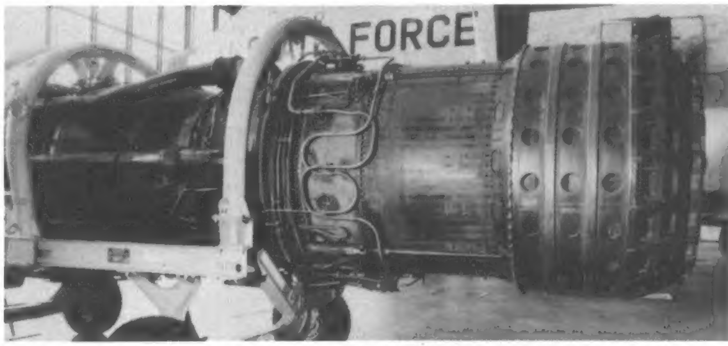
Pratt & Whitney JT11D-20B (J58) in transport dolly.


Jay Miller/Aerofax, Inc.

Compressor face view of JT11D-20B.


Jay Miller/Aerofax, Inc.

Pratt & Whitney JT11D-20B is rated at 32,500 lbs. thrus t at s.l.



Jay Miller/Aerofax, Inc.

By-pass ducting and continuous operation afterburner of JT11D-20B.


Ben Knowles/Aerofax, Inc.

Front view of GTD-21B drone on dolly.


Ben Knowles/Aerofax, Inc.

GTD-21B's have no national markings.


Ben Knowles/Aerofax, Inc.

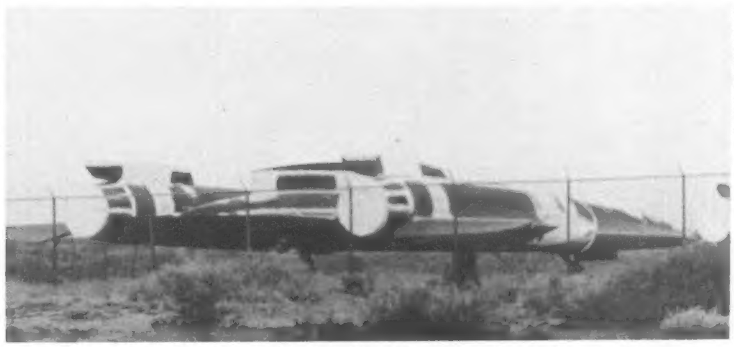
Aft view of GTD-21B and ramjet exhaust nozzle.


Ben Knowles/Aerofax, Inc.

Some 17 GTD-21B's have been stored at Davis-Monthan AFB, Az.


Ben Knowles/Aerofax, Inc.

Nose detail of GTD-21B with intake spike cover in place.


Chris Pocock collection

One of two A-12's modified for D-21 transport (note dorsal pylon).

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AEROFAX, INC. looks forward to hearing from you . . . .

Sincerely,
Jay Miller and
the **AEROFAX**
Editorial Staff